National Aeronautics and
Space Administration

Educator Product	
Educators	Grades 5-8

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Educator Guide

Grades 5–8

Forces and Motion

Personal Satellite Assistant

psa.arc.nasa.gov

PSA Educator Guides are available in electronic format through NASA Spacelink—one of NASA's electronic resources specifically developed for the educational community.

This publication and other educational products may be accessed at the following address:

http://spacelink.nasa.gov/products

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Introduction

The Personal Satellite Assistant Forces and Motion Educator Guide for grades 5-8 has been developed by the National Aeronautics and Space Administration (NASA) for the purpose of increasing students' awareness of and interest in robotics, engineering, and the many career opportunities that utilize science, math, and technology skills. The lessons are designed for educators to use with students in grades 5-8 in conjunction with the Personal Satellite Assistant (PSA) multimedia activities on the Personal Satellite Assistant Education Web site (http://psa.arc.nasa.gov/).

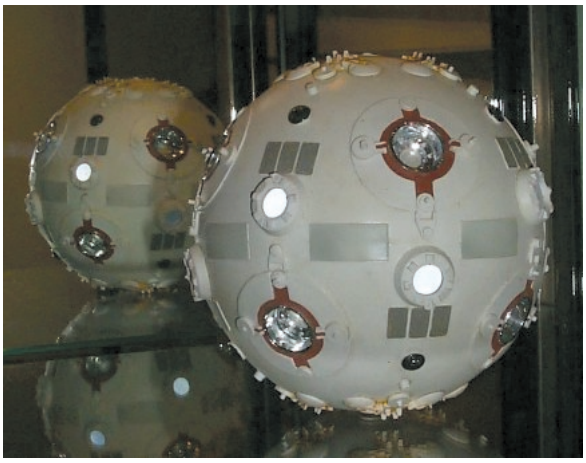
The lessons in this guide are designed to be used together to build a comprehensive understanding of forces and motion concepts. However, the lessons can also be used in isolation to focus on a particular concept.

Personal Satellite Assistant Overview

The Personal Satellite Assistant (PSA) is an intelligent, free-flying robot that NASA has been developing in an effort to improve how we explore and work in space. This spherical robot is being designed to fly around inside the International Space Station, as well as in spacecraft in orbit or traveling to the Moon or Mars. In addition, the control software and the vision system being developed and tested on the PSA can be used by many other kinds of robots, like future Mars rovers.

PSAs are designed to help people in three different ways. The first way is to do inspections and other tasks when the crew is too busy or when it is too dangerous. The second way is to help an astronaut perform tasks by acting as a laptop computer and cameraman that obeys voice commands and records what is being done, leaving the astronaut's hands free to do other things. The PSA has video conferencing capabilities that will allow engineers and scientists on Earth to interact with an astronaut in space. The third way is to diagnose problems on the spacecraft without having to bother the flight crew. If the spacecraft's sensors detect a problem, it can send a PSA to the location to determine the cause. If the cause is a failed sensor, in some cases the spacecraft can use a PSA as a temporary sensor until the spacecraft sensor is repaired. In addition, the spacecraft can use the PSA to track down the location of a heat source or a noise.

The design of the PSA was inspired in part by the small floating sphere that Luke Skywalker sparred with in the original "Star Wars" movie. Some of the PSA's capabilities were inspired by the "tricorders" that landing parties used to survey the atmosphere on planets in the TV series, "Star Trek." However, in space, astronauts like to keep their hands free to move around and perform tasks. The PSA has nine cameras to navigate and to record what is going on around it. Using its cameras, the PSA can figure out where it is and how fast is it moving. It can also avoid obstacles and follow targets. Like the fictional tricorder on "Star Trek," the PSA has sensors that detect the pressure and temperature of the air, as well as concentrations of gases such as oxygen and carbon dioxide. For astronauts living in a sealed aluminum can in the vacuum of space, this kind of information is essential. Additional special sensors could also be added as needed.



Jedi Training Remote
Star Wars, Lucasfilm

Mark X Tricorder
Star Trek, Paramount Communications Inc.

It is difficult to build a robot like this. Instead of trying to get the final robot design right on the first try, multiple robots are built, each being designed to answer a certain set of questions. Some of the models are non-functioning mockups to help understand how it should look and how people interact with it. Others are built to test certain subsystems, like propulsion. Others are fully functional prototypes, where each one is better than the one before it.

For the PSA prototypes to be operated in Earth's gravity, a special microgravity test mechanism was constructed. It looks like a bridge crane the size of a large room. The object (payload) suspended from it floats as it would in space. The crane has special sensors to detect any forces acting on the payload, and accelerates it into the direction of the net force so the payload continues to move in the same direction at a constant velocity, just as it would in space. By using the PSA as the payload, the PSA can fly around just as it would inside a spacecraft in orbit.

Future models of the PSA are being considered that have arms and that could help astronauts on the Moon and Mars. Robots continue to be a key strategic element for NASA to help humans living and working in space.

The PSA family of robot prototypes is being designed and built at NASA Ames Research Center in Mountain View, California. The latest status of its development will be posted at the PSA website.

PSA Web Site Overview

The PSA education Web site (http://psa.nasa.gov) has inquiry-based lessons, interactive multimedia activities, online challenges, and video animations focusing on systems, forces and motion, engineering design, volume, surface area, graphing, characteristics of 2-D and 3-D shapes, and center of mass. These are designed to support both middle school and high school students.

PSA Web Site
http://psa.arc.nasa.gov

NASA Relevance

NASA scientists and engineers working on the PSA project need to reduce the volume and mass of the PSA because of the high cost of transportation to the ISS, limited space in space-based vehicles, and for safety reasons. The PSA must move quickly and efficiently around the ISS in order to carry out its daily tasks. Thus, it must be designed with careful consideration of the fundamental principles of forces and motion.

PSA Web Site Overall Goal

Personal Satellite Assistant uses robotics engineering content, physics in the microgravity environment, problem-based learning, inquiry, and critical thinking skills to increase awareness of NASA careers and to educate students in grades 5-12 on the use of robotics to assist in space exploration missions.

PSA Web Site Overall Objectives

- Students in grades 5-12 will use problem-based learning and the engineering design process to design solutions for math and engineering problems related to the design of a robot that will operate in a microgravity environment.
- Students will observe and apply math patterns and relationships as they explore concepts such as unique properties of 3-D objects, surface area, volume, center of mass, and motion over time.
- Students will make observations of motion with very little or no friction, will draw conclusions about the laws of motion, and will describe and graph motion.
- Students will describe a NASA occupation that interests them.

Education Standards

In addition to meeting the National Science Education Standards, International Technology Education Association, and International Society for Technology in Education standards, PSA Educator Guides are written to meet benchmarks found in the Benchmarks for Science Literacy produced by the American Association for the Advancement of Science (AAAS) as part of their science, math, and technology reform movement called Project 2061. The mission of Project 2061 is to "shape the future of education in America, a future in which all students [will] become literate in science, mathematics and technology by graduation from high school" (p. VII).[1] "The Benchmarks for Science Literacy are statements of what all students should know or be able to do in science, mathematics and technology by the end of grades 2, 5, 8 and 12" (p. XI)[2] and are based on extensive research of when and how it is developmentally appropriate to teach the concepts and skills described.

The tables below show the benchmarks and standards for the PSA lessons. The first portion of the table entry identifies which standards or benchmarks are referenced. "2061" is a reference to the Benchmarks for Science Literacy. "NSES" is a reference to the National Science Education Standards. "ITEA" is a reference to the International Technology Education Association national education standards. "ISTE" is a reference to the International Society for Technology in Education standards. "NCTM" is a reference to the National Council for Teachers of Mathematics. The second portion of the table entry identifies the specific standard referenced. In the case of Project 2061, the standard is referenced, the grade range and then the number of the concept under this standard and grade range. We distinguish between "meeting" benchmarks or standards, "partially meeting" them, and "addressing" them to alert educators to concepts that are taught or partially taught for deep understanding in a lesson compared to topics or ideas that we might touch upon but do not really teach for deep understanding.

[1] Project 2061, American Association for the Advancement of Science. (1993). Benchmarks for Science Literacy. New York. Oxford University Press. (p. VII).

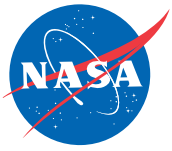
[2] Project 2061. (p. XI).

PSA Forces and Motion Middle School Objectives/Standards

Lesson	Main Concept	Objectives	Benchmarks/ Standards
1. Identifying Forces on Earth and Space	Objects move differently on Earth than they do in space because of the effects of gravity and friction.	• Students will describe the motion of CDs sliding on a flat surface, CDs gliding on air, and a robot on the ISS. They will draw conclusions about how friction affects motion. • Students will compare the forces on a robot on Earth with the forces on a robot on the ISS, and their resulting motion. They will explain how and why these robots will need to be controlled differently.	Meets: ISTE 3, 5 Partially Meets: 2061: 4F (3-5) #1 2061: 4F (6-8) #3
2. How Objects with Different Masses Move in Microgravity	For any given force, mass affects the speed and direction of an object in microgravity.	• Students will design an experiment to determine how mass affects the motion of an object in a frictionless environment. • Students will write a letter to NASA recommending a more massive or less massive PSA with an explanation of their reasoning, including how mass affects forces on an object. • Students will explain how forces and motion apply to sports and games.	Meets: ISTE 3, 5 Partially Meets: NSES: B (5-8) #2.2, #2.3 2061: 4F (3-5) #1
3. Unbalanced Forces and How They Affect Motion	An unbalanced force acting on an object changes its speed or direction of motion, or both.	• Students will describe how forces affect the direction of motion and speed of the PSA in microgravity. • Students will draw the forces and path they use to hit targets with their CD Gliders. • Students will draw and explain the forces and path that will maneuver the PSA around obstacles to a target.	Meets: ISTE 3, 5 Partially Meets: NSES: B (5-8) #2.2, #2.3 2061: 4F (3-5) #1 2061: 4F 6-8 #3

More information on the benchmarks and standards referenced can be found at the following Web addresses:

Standard/Benchmark Title	Web Address
American Association for the Advancement of Science: Project 2061	http://www.project2061.org/
National Science Education Standards (NSES)	http://www.nap.edu/readingroom/books/nses/html/
National Council of Teachers on Mathematics (NCTM)	http://standards.nctm.org/index.htm
International Society for Technology in Education (ISTE)	http://cnets.iste.org/
International Technology Education Association (ITEA)	http://www.iteawww.org/TAA/TAA.html



Educational Standards List

Benchmarks for Science Literacy (2061)

4. The Physical Setting

F. Motion

3-5

#1: Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have.

6-8

#3: An unbalanced force acting on an object changes its speed or direction of motion or both.

11. Common Themes

A. Systems

6-8

#2: Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.

#3: Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

National Science and Education Standards (NSES)

Content Standard B: Physical Science

5-8

2. Motions and forces

#2.2: An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.

#2.3: If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

International Society for Technology in Education (ISTE) Standards

TECHNOLOGY FOUNDATION STANDARDS FOR STUDENTS

3. Technology productivity tools

- Students use technology tools to enhance learning, increase productivity and promote creativity.
- Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications and produce other creative works.

5. Technology research tools

- Students use technology to locate, evaluate and collect information from a variety of sources.
- Students use technology tools to process data and report results.
- Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.